2. Notes on *Carcharodon rondeletii*. By T. Jeffery Parker, B.Sc., C.M.Z.S., Professor of Biology in the University of Otago, New Zealand.

(Plates IV.–VIII.)

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Contents.

Dr. Günther states, in his 'Study of Fishes,' published in 1880, that nothing is known of the anatomy, habits, and reproduction of this, the most formidable of all Sharks, and that no opportunity should be lost in obtaining information about it.

As no fewer than four specimens of *Carcharodon rondeletii* have been caught in the neighbourhood of Dunedin during the last six years, upon all of which I have been able to make some observations, I have decided to put these upon record, in spite of the fact that they are, from a variety of circumstances, detached and imperfect, and are very far from giving anything like a complete account of this very interesting Selachian.

The following enumeration of the specimens which have come under my notice is given for convenience of reference.

Specimen A.—Male, 10 ft. (3 metres) long. Caught at Moeraki, about 40 miles north of Dunedin, early in 1881. The viscera, including the heart, were removed before bringing the fish to Dunedin. The skeleton was prepared and is now in the Otago University Museum.

Specimen B.—Female, 12 ft. 6 in. (3·8 metres) long. Caught in Otago Harbour early in 1885. This specimen was also eviscerated, only the heart being left. Its skeleton was prepared and sent to the Colonial and Indian Exhibition[1].

Specimen C.—Female, 19 ft. (5·7 metres) long. At the beginning of the present year two large Sharks were reported in the Lower Harbour, and several attempts to catch them were made by the local fishermen. After one or two failures (the Shark on one occasion having broken away with a large hook in its mouth) the larger of the two was caught and exhibited in Dunedin. After it had been on view for a few days I bought it for the museum, and was able to make some observations on its external anatomy, in spite of the advanced state of decomposition. This specimen was stuffed, and is now in the Otago University Museum.

[1] This specimen is now in the Natural-History Museum, South Kensington.

Specimen D.—Female, 17 ft. (about 5 metres) long. The second specimen referred to in the preceding paragraph was caught about a fortnight later than the first, and was also brought entire to Dunedin for exhibition. The funds of the museum would not allow of its purchase, and indeed my assistants were at the time so fully occupied with the preparation of the larger specimen, that it would have been impossible for them to undertake a second task of similar magnitude; so that all I could do was to be present when, on the third day after capture, the viscera were removed, and to make some notes on those organs which were too much decomposed in the former specimen.

Specimen E.—Fœtus (female), 55 cm. long. For this I am indebted to Mr. E. P. Ramsay, F.L.S., Curator of the Australian Museum, Sydney.

I may also mention that, as I am informed by my friend Prof. A. P. Thomas, a specimen of *Carcharodon*, fully 30 ft. long, was caught at Auckland a few months ago. It would seem, therefore, that in spite of its apparent scarcity in museums, *Carcharodon rondeletii* must be a tolerably common species in the Southern Seas.

1. *External Characters.*

As the small specimen described by Smith, in his 'Zoology of South Africa,' appears to be the only one of which careful measurements have been taken, it seems advisible to give a fairly complete series of measurements of specimen C, the largest which has come under my notice.

	centim.
Total length from tip of snout to tip of upper lobe of tail-fin (following the curve)	577
Total length in a straight line	552
From tip of snout to 1st dorsal fin (anterior border)	202
From tip of snout to anterior border of pectoral fin	155
From posterior border of pectoral to anterior border of pelvic fin	152
From posterior border of pelvic to anterior border of ventral (anal) fin	60·8
From posterior border of ventral (anal) to root of caudal fin	40·4
Girth immediately cephalad of 1st dorsal fin	296
Height of first dorsal fin	45·6
Breadth ,, ,, at base	53
Height of second dorsal fin	7
Breadth ,, ,, at base	8
Length of pectoral fin, along anterior border	103
Breadth ,, ,, at base	58
Length of pelvic fin, along outer border	30
,, ,, ,, inner border	41
Breadth ,, ,, at base	19
Height of ventral (anal) fin	11
Breadth ,, ,, ,, at base	9

	centim.
From tip of snout to centre of eye	23
,, ,, ,, upper angle of nostril	22
,, ,, ,, centre of mouth	30
,, ,, ,, 1st gill-slit (dorsal end)	116
From centre of eye to spiracle	33
Width of mouth-aperture, in a straight line	58
Height of 1st gill-slit	64
Width of flattened caudal region (*vide infra*), measured with calipers	42
Height of ditto, measured with calipers	18·5
Height of caudal fin from tip of dorsal to tip of ventral lobe	146
Height of dorsal lobe of ditto, measured along anterior border from root to tip	106
Height of ventral lobe, similarly measured	95

The skin is dark grey above, white tinged with pink below, the latter colour being evidently due to blood in the skin and not to the presence of any special pigment. The under surface of the snout is dark, not white and pink as in Smith's specimen.

The snout is considerably less pointed than in *Lamna*, or than in the young specimen figured by Smith. The eye is also markedly smaller in proportion to the size of the head than in *Lamna* (*cf.* description and figures of skull, *infra*, p. 32 and Plates IV. and V. figs. 1–5 and 11).

The form of the caudal region is remarkable, and is not adequately described in any of the books at my disposal, in which it is merely stated that the tail is provided with lateral ridges. It is more correct to say that the tail for a short distance in front of the caudal fin is strongly depressed, so much so that its width is more than double its height, a transverse section having the form shown in fig. 19, Plate VII.

It looks very much as if this curious modification must have the result of providing *Carcharodon* (and *Lamna*, in which the same structure obtains) with a combination of vertical and horizontal tail-fin, the latter—the flattened region just described—being developed as a means of enabling the fish to rise rapidly from great depths.

2. *The Teeth.*

Only the central tooth of each row in each jaw is symmetrical, all the others having their long axes directed outwards. The exposed portion of the upper middle tooth (specimen C) is 4 cm. in height, and 3·7 cm. wide at the base. In the lower middle tooth these dimensions are respectively 3·4 (height), and 3·2 (width at base). In both jaws the outer surfaces of the teeth are markedly flatter than the inner.

3. *The Skeleton.*

The vertebral column of *Carcharodon* has been fully described by

Hasse[1] and a briefer account of the entire skeleton is given by Haswell[2]. I shall therefore confine myself to a few points which do not appear to have been insisted on, mentioning especially such as seem to be important for comparison with *Lamna*.

a. *The Vertebral Column.*—In specimen A there are about 182 vertebral centra; at the end of the tail it becomes difficult to count them accurately. The centra agree with Hasse's description, except that I do not find the difference in the disposition of the radiating lamellæ of bone which that author gives as distinguishing the trunk- from the tail-vertebræ. Hasse describes and figures only two very thick dorsal lamellæ in the caudal vertebræ, between the origin of the neurapophyses: in my specimens there are three or four comparatively thin lamellæ as in the trunk-vertebræ (*cf.* figs. 13 and 14, Plate VI.).

One point not very clearly brought out by Hasse is the extreme irregularity in the segmentation of the neural tube and of the hæmal tube or ridges. These are, in the embryo, continuous cartilages[3], which undergo segmentation at a later stage than the centra, becoming divided into vertebral portions, the neur- and hæmapophyses, and intervertebral portions, the interneural and interhæmal pieces, or intercalaria. The irregular way in which this segmentation takes place in *Carcharodon* is very striking, and is well shown in figs. 7 and 8 (Plate V.), the former representing a portion of the neural tube seen from above, the latter a portion of one of the hæmal ridges seen from below. Occasionally the distal portion of a hæmapophysis becomes segmented off, forming a rib (fig. 8, *r*).

Another matter not touched upon by Hasse is the modification undergone by the vertebral column at its anterior and posterior extremities. Anteriorly there is no clear line of demarcation between skull and vertebral column. At the level of the third vertebral centrum (fig. 6, *vert.cent.* 3) the neural tube meets on each side with the corresponding hæmal ridge, forming a continuous lateral investment of cartilage over the first two centra, which are thus only visible from beneath. The continuous lateral cartilage thus formed passes insensibly into the exoccipital region of the skull, while the first and second centra pass into the basioccipital region, and the neural tube into the supraoccipital region. Thus, when the skull is separated artificially from the vertebral column in such a way as to leave intact the great parotic processes (fig. 1, *p.ot.pr*), the plane of section passes naturally between the second and third vertebral bodies, and the first two centra appear to be imbedded in the basis cranii (fig. 3).

It is also worthy of notice that in the first few vertebral segments the intercalary pieces (fig. 6, *i*) are small triangular processes

[1] Das natürliche System der Elasmobranchier. Jena, 1879.

[2] "Studies on the Elasmobranch Skeleton," Proc. Linn. Soc. N. S. W. vol. ix. (1884) p. 3.

[3] Balfour, 'Comparative Embryology,' vol. ii. p. 454. (Memorial edition, vol. iii. p. 550.

inserted between the bases of adjacent neural arches, the latter (*n.a*) forming the whole dorsal region of the neural tube; whereas in the remaining greater part of the column the intercalaria form actual interneural arches.

The tail-fin contains nearly three-fourths as many vertebræ as all the rest of the column, the 107th centrum being the first of the tail-fin (Plate VI. fig. 12, *vert.cent.* 107), recognizable by being the first to develop a hæmal spine. In this and the five following vertebræ the hæmal spine (*hæ.sp*) is a separate cartilage, quite distinct from the hæmapophyses; in the remaining tail-vertebræ the two are continuous. The hæmal spines gradually increase in length to the 120th vertebra, and then undergo progressive diminution: the longest, in specimen A, is 10 cm. in length.

The tail-fin is thus supported ventrally by hæmal spines: the small portion lying dorsad of the vertebral column, on the other hand, has its framework constituted by a series of cartilages (*ptg*) which are evidently not neural spines but *pterygiophores*[1] or cartilaginous fin-rays. These have no definite relation to the vertebral segments, one of them sometimes corresponding to a single vertebra, sometimes to two, and sometimes to three.

Hasse remarks that while intercalaria are absent in the hæmal tube in the caudal region, they are present in the neural tube, which has therefore double neural arches as in the trunk region. This is true only as far back as the 130th vertebra (*vert.cent.* 130), caudad of which intercalary pieces are absent and the neural arches consequently single.

In the 167th (*vert.cent.* 167) and following vertebræ, the neural and hæmal arches are united with one another on each side by a vertical bridge of cartilage, so that the middle portion of each centrum is hidden. From the 175th vertebra to the end of the series there are no longer distinct neural and hæmal arches, but simply an irregular vertical plate of cartilage, in which the last eight (?) vertebral bodies are imbedded. An examination of this region in the fœtal specimen (E) shows (Plate VIII. fig. 28) that these are all perfectly formed centra except the last, which is a somewhat irregular mass of bone, and appears to me to be a *demi-vertebra*[2], *i. e.* to represent the anterior half of a centrum formed in the posterior moiety of the last mesoblastic somite.

In the skeletons of A and B the neural and hæmal arches are entirely uncalcified; in the large specimen C there are small calcific patches on the anterior neural arches only; from about the 4th or 5th vertebra backwards the only calcifications are those of the centra.

b. *The Skull.*—The cranium is described in detail by Haswell[3], who gives figures of it from above and from the right side, which are, however, too small to show certain important details, such as the nerve-foramina. For this reason, and because of the desirability

[1] T. J. Parker, "On the Skeleton of *Regalecus argenteus*," Trans. Zool. Soc. vol. xii. p. 24, note.
[2] *Cf.* "Skeleton of *Regalecus*," p. 22.
[3] *Op. cit.*, Journ. Linn. Soc. N. S. W. vol. ix. p. 15.

of comparing the skull with that of the closely allied Porbeagle (*Lamna cornubica*), I give upper, under, and side views of the cranium of both Sharks, drawn to the same absolute length; in the side views the jaws also are shown (Plates IV. and V.).

Haswell says, "On comparing the skull of *Carcharodon* with a dried skull of *Lamna cornubica*, I can find little difference between the two." As a matter of fact the differences between the two crania are by no means inconsiderable, as Haswell would no doubt have found if his skull of *Lamna* had not been distorted by drying.

The main differences are dependent upon the much greater proportional size of the rostrum and of the orbits in *Lamna*. In *Carcharodon* the dorso-lateral arms of the rostrum (first labial cartilages, W. K. Parker[1]) are slightly curved, with a downward concavity, while the median ventral arm (prenasal cartilage) has a strong downward convexity, so that the three bars meet at a wide angle. All three bars are broad at the base, but narrow considerably in front, and are but slightly calcified, the distal portion of the entire rostrum being composed wholly of cartilage.

In *Lamna*, on the contrary, all three rostral bars have a marked sigmoid curve, and meet with one another at very acute angles. They are also much longer proportionally than in *Carcharodon*, much thicker, and are covered externally with a close mosaic of bony matter.

As already remarked, the eyes, and consequently the orbits, are proportionally much larger in *Lamna* than in *Carcharodon*; as a result of this, the orbital roofs (*sup.orb.pl*) in *Lamna* are strongly arched both antero-posteriorly and laterally, and the infraorbital plates (*inf.orb.pl*) inclined downwards at their outer ends. The whole cranium also, and especially the basal plate (*i. e.* the basis cranii proper *plus* the infraorbital plates), is much narrower than in *Carcharodon* (*cf.* figs. 3 and 4), and the parotic (*p.ot.pr*) and postorbital (*p.orb.pr*) processes are less prominent.

In the fœtal specimen (Plate VIII. figs. 24 and 25) the rostrum is very slender, and its ventral or prenasal bar is perforated distally by a foramen. The anterior fontanelle (*font.*) is very large, and allows the cerebrum to be partly seen in a view from above. The auditory capsules are very prominent, and show clearly the elevations for the semicircular canals. The supraorbital plate is hardly developed, and the infraorbital plate is quite narrow.

To the outer surface of the auditory capsule of the fœtus, dorsad of the hyomandibular facet, a small rod of cartilage (Pl. VIII. fig. 26, *spir.cart.*) is attached by fibrous tissue. This appears to be the dorsal segment of the mandibular arch or spiracular cartilage. Unfortunately the specimen had been dissected by one of my assistants, as a help to the articulation of the adult skeleton, before I observed this cartilage, so that I was unable to make out its relations to the spiracle. No corresponding structure was found in the adult, but

[1] "On the Structure and Development of the Skull in Sharks and Rays," Trans. Zool. Soc. vol. x. (1877) p. 189. Parker and Bettany, 'Morphology of the Skull,' p. 35.

in so large a specimen a small cartilage imbedded in the immense jaw-muscles would be easily missed.

The foramina in the skull-wall have the same general disposition as in *Lamna* (*cf.* figs. 5 and 11, Plate V.), the main differences between the two being the greater proportional size of the optic foramen (*ii.*) in the latter genus, and the fact that the oculomotor foramen (*iii.*) is on the same level as the optic in *Carcharodon*, while in *Lamna* it is in the same horizontal plane as the ophthalmic peduncle (*op.ped.*). In both the carotid foramen (*cor.f.*) is a short distance caudad of the optic. Between and below the foramina for the 3rd (*iii.*) and the 5th (*v.*) nerves there is, in *Lamna*, a small aperture which does not seem to be represented in *Carcharodon*: possibly it transmits the 6th nerve. The glossopharyngeal and the vagus foramina (Plate IV. figs. 1 and 2, *ix.*, *x.*) are both large, the latter in particular being of immense size.

The jaws of *Carcharodon* (fig. 5) are chiefly remarkable for their great size, and especially for the extraordinary depth of the mandible. In *Lamna* (fig. 11) their proportional size is considerably less.

In another closely allied genus, *Alopecias*, the cranium has a more rounded form than in *Lamna*, and is similarly modified in accordance with the great size of the eyes. The rostrum is very thin and delicate, and is hardly at all calcified: its ventral or prenasal bar is perforated at its distal end by a vertical foramen. The jaws have about the same proportional size as in *Lamna*.

The gill-bearing arches of *Carcharodon* closely resemble those of *Lamna* and of *Scyllium*[1]. The hyomandibular and ceratohyal (Plate VIII. fig. 27, *c.hy*) are large and stout, and the tongue is supported by a flat basihyal (*b.hy*) having a convex anterior and an excavated posterior border. The first branchial arch consists of a flat, subtriangular pharyngohyal, a stout epibranchial, and a similar but longer ceratobranchial (*c.br.* 1) which articulates with the basihyal, there being no first hypobranchial. The next three arches have, in addition, a short rod-like hypobranchial segment (*h.br.* 2–4). Between the ventral or inner ends of the second hypobranchials (*h.br.* 2) is a small nodular basibranchial (*b.br.* 2). The second and third hypobranchials are subequal, the fourth (*h.br.* 4) is barely half the length of its predecessors. The fourth and fifth pharyngobranchials have undergone concrescence; the fifth ceratobranchial (*c.br.* 5) is, as usual, much larger than the corresponding segment in the preceding arches. The last arch has no hypobranchial, its ceratobranchial segment (*c.br.* 5) abutting against an elongated flattened plate (*b.br.* 5), rounded in front and pointed behind, and probably to be regarded as a fifth basibranchial.

To the inner face of the fifth ceratobranchial, near its dorsal end, a small irregular rod of cartilage is attached by fibrous tissue. Can this be the rudiment of a sixth branchial arch?

The gill-arches are but slightly calcified, even the hyomandibular and ceratohyal having only a thin crust of bony matter which does not extend to their extremities.

[1] W. K. Parker, *op. cit.*; Gegenbaur, 'Kopfskelet der Selachier,' Leipzig, 1872.

c. *The Skeleton of the Fins.*—In the shoulder-girdle I have nothing to add to Haswell's description. The pectoral fin of specimen A exhibits a concrescence of the proximal ends of the mesopterygial rays not shown in Haswell's figure. The intercalary pieces between the distal ends of many of the rays, referred to by Haswell, are evidently due to longitudinal division of the rays, one of which, in the specimen referred to, was distinctly bifurcated.

The pelvic girdle and fin are not figured by Haswell: I therefore give a figure of those of the male specimen A (Plate V. fig. 9). Haswell states that the outer extremity of the pelvic cartilage (*pu*) "is produced into a process with which no fewer than six rays articulate." In my specimen this process is apparently represented by a separate cartilage (*a*), which seems to be formed by the concrescence of the anterior rays, and to be serially homologous with the propterygium of the pectoral fin.

The first dorsal fin differs only in detail from that described and figured by Haswell, who says of the second dorsal and ventral (so-called anal) fins, that they "are very small, and consist of a few irregular rays without basal plates." I find, on the contrary, that both these fins (Plate V. fig. 10, and Plate VI. fig. 15) and especially the ventral (fig. 10) are quite typical examples of the concrescence of pterygiophores (radial cartilages) to form a basipterygium.

4. *Alimentary Organs.*

The stomach (specimen C) consists of a wide cardiac (Plate VI. fig. 16, *card.st.*) and a narrow tubular pyloric (*pyl.st.*) division. The cardiac division is about 115 cm. long and 75 cm. wide; the pyloric division 104 cm. long by 5 cm. wide. On the right side of the stomach, near its œsophageal end, are two blind pouches (*x.*).

The intestine (*int.*) is 109 cm. long from the pylorus to the origin of the rectal gland, and 26 cm. in diameter. The spiral valve is regularly disposed, makes 48 turns, and is slightly narrower than the semi-diameter of the gut, so that a narrow central passage is left, as in *Alopecias* and in some specimens of *Raia* [1].

The rectal gland (*rct.gl.*) is 30 cm. long by 3·5 cm. in diameter. The cloaca (fig. 17) is comparatively small, and is divided by a horizontal fold into two chambers, an outer (cl^2) receiving the oviducts (*ovd.ap.*), and an inner (cl^1) receiving the rectum (*rct*) and the urinary duct (*ur.ap.*).

The liver consists of two immense lobes, which fill all the ventral region of the abdominal cavity. In specimen C the gland was too much decomposed for its form and size to be made out, but in D (5 metres long) each lobe was about 135 cm. long, by 102 cm. wide, and fully 30 cm. thick. A gall-bladder is present.

The spleen and pancreas have the usual characters; the pancreas (Plate VI. fig. 16, *pan.*) consisting of a small ventral and a large

[1] T. J. Parker, "On the Intestinal Spiral Valves in the Genus *Raia*," Trans. Zool. Soc. vol. xi. p. 50.

dorsal lobe, and the spleen (*spl.*) being an elongated lobulated organ of deep red colour, attached all along the right border of the pyloric division of the stomach and continued on to the dorsal aspect of the cardiac division.

5. *The Heart.*

The heart is very large, having the following dimensions in specimen C.

	centim.
Greatest width of ventricle	19
,, length (antero-posterior)	15
,, ,, of conus arteriosus	10·5
,, width of conus arteriosus	5
,, ,, of auricle (moderately distended)	22
Width of sinu-auricular aperture	9
,, of auriculo-ventricular aperture	4·5
Thickness of wall of ventricle (about)	3·5

Its general structure is quite normal. The sinu-auricular valves are obliquely right and left; the auriculo-ventricular valves obliquely dorsal and ventral. The coronary veins open apparently by a single very large aperture situated in the sinus venosus immediately caudad and dorsad of the left flap of the sinu-auricular valve.

The conus arteriosus (Plate VI. fig. 18, *con.art.*) has three longitudinal rows, each of three valves, one row being dorsal, the others ventro-lateral. The posterior valves (v^1) are pocket-like and very thick; each is connected to the posterior face of the corresponding middle valve (v^2) by a strong *chorda tendinea*, which in the dorsal valve takes the form of a vertical membrane attached to the wall of the conus along its whole length, while in the ventro-lateral valves it is free except at the ends.

The middle valves (v^2) are very small and thick, forming knobs rather than pouches; their anterior edges are connected to the walls of the conus by several *chordæ tendineæ.* The anterior valves (v^3) are pocket-like and are in close contact with one another at their edges, whereas each of the middle and posterior valves is separated from its fellow by a considerable interval. The edges of each of the anterior valves are produced forwards, forming a firm attachment, but they have no *chordæ tendineæ.*

There are, as usual, too large coronary arteries placed right and left of the conus.

6. *The Urinogenital Organs.*

The ovary was too much decomposed in specimen C for anything to be made of it; in D it was quite small, so that the specimen must have been immature in spite of its size. The oviducts have the usual character; in D there was a considerable dilatation in the position of the oviducal gland in one oviduct, but only a very slight enlargement in the other. The oviducts open into the external compartment of the cloaca by papilliform terminations (Plate VI. fig. 17, *ovd.ap.*).

The urinary bladder (specimen C) is small and opens into the internal compartment of the cloaca by a small papilla (fig. 17, *ur.ap.*).

7. *The Brain.*

The brain could only be examined in specimen C, in which, as already mentioned, decomposition was far advanced before the fish came into my possession. As soon as the cranium could be removed, a saturated solution of corrosive sublimate was poured into the brain-cavity through the foramen magnum, so as to harden the brain *in situ*. Next day the roof of the cranium was sawn off, and the brain sketched from above (Plate VII. fig. 20); a plate of mica was then inserted beneath it, the nerves cut, and the organ transferred to strong alcohol with comparatively little shaking. By using these precautions, and thanks in great measure to the thickness of the pia mater, I was able to make a tolerably accurate examination of the brain, although all the softer abdominal viscera were hopelessly decomposed some days before the brain could be got at. The encephalon of the fœtal specimen E was also examined (Plate VIII. fig. 29).

The adult brain is about 13 cm. long from the anterior boundary of the prosencephalon (Plate VII. figs. 20–22, *prosen.*) to the posterior end of the metencephalon[1] or medulla oblongata (*meten.*); to this must be added about 12 cm., the length of the olfactory lobes (*rhinen.*), giving a total length of 25 cm. The greatest width, across the cerebrum, is about 3·5 cm. In the fœtus (fig. 29) the brain is nearly 5 cm. long by 2 cm. wide.

The main difference between the fœtal and the adult brain depends upon the elongation, in the latter, of the medulla oblongata and of the olfactory lobes. As will be seen by comparison of figs. 20 and 29, fully one half of the medio-dorsal region of the metencephalon is covered by the cerebellum in the fœtus, hardly more than one sixth of it in the adult. Again, in the fœtus, the olfactory bulbs are almost sessile upon the prosencephala, their crura being very short; in the adult, on the other hand, the rhinencephalic crura are of great length.

In a female specimen of *Lamna cornubica*, 135 cm. ($4\frac{1}{2}$ ft.) long, I find that the brain resembles that of the fœtal rather than that of the adult *Carcharodon*; the olfactory crura are comparatively short, not longer than the prosencephala, and fully one half of the metencephalon is covered by the cerebellum. In the fresh brain the optic lobes were so completely covered by the cerebellum as not to be visible in a view from above, but after hardening in corrosive sublimate the epencephalon had undergone a slight shrinking, allowing the lateral regions of the lobes to be seen. The vertical height of the entire brain is great in proportion to its width; probably in the adult *Carcharodon* the decomposed brain had spread out a good deal under the action of gravity.

In the metencephalon of *Carcharodon* the restiform bodies (fig. 20,

[1] Vide T. J. Parker, "On the Nomenclature of the Brain and its Cavities." 'Nature,' vol. xxxv. 1886, p. 208.

rest.) are large and folded. The metacœle or fourth ventricle (*mt. cœ.*) is covered by a thick tela vasculosa (*tel.vasc.*) and its floor is marked by five well-marked grooves.

The epencephalon or cerebellum (*epen.*) is large, divided into lobes by transverse sulci, and prolonged forwards so as to cover all the median portion of the mesencephalon as well as backwards over the anterior sixth of the metencephalon. It contains a large epicœle (cerebellar ventricle), which communicates by a comparatively small aperture or ostium with the metacœle.

The mesencephalon presents dorsally a pair of large optic lobes, or optencephala (*opten.*), and contains a spacious mesocœle (fig. 21, (*mes.cœ.*), on the middle of the floor of which is a small aperture (x) leading into the diacœle or third ventricle (*di.cœ.*). This apparently unusual arrangement no doubt indicates that the optic lobes have overlapped the posterior portion of the diencephalon.

The diencephalon (*dien.*) is short; its cavity, the diacœle (*di.cœ.*), is arched over posteriorly by a narrow bridge of nervous matter, but for the most part is covered in only by the thick vascular velum interpositum (*vel.int.*). On its floor is a longitudinal groove (y) leading both into the mesocœle and into the infundibulum, which is short and bears a large trilobed hypophysis or pituitary body (*hyp.*). No hæmatosac (saccus vasculosus) was apparent, and the conarium or pineal body was not observed. On the ventral surface of the diencephalon are small rounded lobi inferiores (*lob.inf.*).

In the fœtal brain, as well as in that of *Lamna*, the diencephalon is quite concealed in a view from above, the anterior faces of the optic lobes being quite vertical and in close contact with the posterior face of the cerebrum (fig. 29).

The cerebrum is a large, transversely elongated mass, consisting of the fused prosencephala or cerebral hemispheres (*prosen.*), the line of junction between which is marked both above and below by a distinct groove. Each prosencephalon is also divisible into a large dorso-lateral and a smaller ovoidal ventral lobe (fig. 22).

The cerebrum contains well-developed lateral ventricles or prosocœles (fig. 21, *prs.cœ.*), communicating each by a foramen of Monro (*for.M.*) with a small triangular space, the aula, lying immediately cephalad of the diacœle proper, and consisting of the cavity of the basi-cerebrum or unpaired portion of the protencephalon (embryonic fore-brain) left by the budding-off of the cerebral hemispheres.

A choroid plexus (*ch.plx.*) is continued into each prosocœle from the velum interpositum. On the inner wall of the cavity is a large ovoidal elevation (a), and a smaller one (b) occurs on its floor.

The rhinencephalon consists, as already stated, of a greatly elongated crus, and of a bulb in apposition with the olfactory sac. A cavity, the rhinocœle (*rh.cœ.*) is continued into the crus from the corresponding lateral ventricle.

The first four cerebral nerves present no special features of importance. The fifth, seventh, and eighth arise, as usual, close together, having between them four principal roots.

The trigeminal (figs. 20, 22, and 23, v) arises by two roots—an anterior and ventral (fig. 23, v^a), formed of two distinct strands, and a posterior and dorsal[2] (v^b), which arises mainly from the dorsal aspect of the metencephalon (fig. 20), immediately caudad of the corpus restiforme, but also receives a small bundle of fibres arising from the lateral region of the metencephalon, in common with the root of the eighth (*viii.*). The facial (*vii.*) has one main root formed of two strands, the ventralmost of which is intimately united with the single root of the auditory nerve (*viii.*).

Both dorsal and ventral roots of the fifth divide before leaving the skull, so that the nerve passes through the trigeminal foramen in four parts (fig. 20), each of which perforates separately the membrane of the foramen.

The sixth nerve (*vi.*) arises by three distinct roots, the posterior of which is very slender and soon unites with the middle root.

The vagus (*x.*) is an immense nerve arising by six lateral roots, of which the first four and the last two unite to form separate bundles, which leave the cranial cavity before joining into a common trunk. On the right side (fig. 20) the posterior root is double, and its hindmost factor arises at least 1 centim. caudad of the calamus scriptorius.

A short distance cephalad of the origin of the posterior root of the vagus there arises from the ventral aspect of the metencephalon a distinct though small root (x^1), formed by the union of several strands. This evidently corresponds with the nerve thus described by Balfour [3]:—"The main stem of the vagus at a short distance from its central end receives a nerve which springs from the ventral side of the medulla, on about a level with the most posterior of the true roots of the vagus. This small nerve corresponds with the ventral or anterior roots of the vagus described by Gegenbaur, Jackson, and Clarke (though in the species investigated by the latter authors these roots did not join the vagus, but the anterior spinal nerves). Similar roots are also mentioned by Stannius, who found two of them in the Elasmobranchs dissected by him; it is possible that a second may have been present in *Scyllium*, but have been overlooked by me, or perhaps may have been exceptionally absent in the example dissected."

As the nerve-roots in *Carcharodon* were made out while the tough pia mater was quite intact, I feel satisfied that no other ventral root of the vagus was present in my specimen. From the direction taken by the nerve it appears to join the vagus, not the spinal nerves; but it was unfortunately severed, as shown in fig. 22, when the brain was removed.

DESCRIPTION OF THE PLATES.

Plate IV.

Fig. 1. Cranium of *Carcharodon rondeletii*, dorsal aspect, $\times \frac{1}{4}$.
2. Cranium of *Lamna cornubica*, dorsal aspect, $\times \frac{2}{5}$.

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[2] This root properly belongs to the seventh, as shown by Balfour and Marshall.
[3] 'Elasmobranch Fishes,' p. 196 (Works, Memorial Edition, vol. i. p. 419).

Fig. 3. Cranium of *Carcharodon rondeletii*, ventral aspect, $\times \frac{1}{4}$.

4. Cranium of *Lamna cornubica*, ventral aspect, $\times \frac{2}{5}$.

References to Figs. 1–4.—*aq. fall*, aqueductus Fallopii; *font*, fontanelle; *inf.orb.pl*, infraorbital plate; *olf*, olfactory capsule; *p.orb.pr*, postorbital process; *p.ot.pr*, parotic process; *rost*^{d}, dorsal bar of rostrum; *rost*^{v}, ventral par of rostrum; *vert.cent.* 1, first vertebral body; *ix.*, glossopharyngeal foramen; *x*, vagus foramen.

Plate V.

Fig. 5. Cranium of *Carcharodon rondeletii* from the left side, with the upper and lower jaws, $\times \frac{1}{4}$. *car.f*, carotid foramen; *h.m*, facet for hyomandibular; *inf.orb.pl*, infraorbital plate; *olf*, olfactory capsule; *op.ped*, facet for ophthalmic peduncle; *p.orb.pr*, postorbital process; *rost*^{d}, dorsal, and *rost*^{v}, ventral bar of rostrum; *sup.orb.pl*, supra-orbital plate; *ii.* optic foramen; *iii.* oculomotor foramen; *iv.* foramen for fourth nerve; *v.* trigeminal foramen; *vii.* facial foramen.

6. Anterior extremity of vertebral column of the same showing its junction with the cranium, $\times \frac{1}{4}$. *i*, intercalary cartilage; *n.a*, neural arch; *vert.cent.* 3, third vertebral body; *x*, vagus foramen.

7. Part of the neural tube of the same, from the dorsal aspect, $\times \frac{1}{4}$. *I*, intercalaria; *n. a*, neural arches.

8. Part of one of the hæmal ridges of the same, from the ventral aspect, $\times \frac{1}{4}$. *Hæ*, hæmapophyses; *i*, intercalaria; *r*, rib.

9. Hip-girdle and left pelvic fin of the same, $\times \frac{1}{4}$. *a*, propterygial cartilage; *bs.ptg*, basipterygium; *clp*, cartilage of clasper; *pu*, pubic bar.

10. Ventral (so-called anal) fin of the same, $\times \frac{1}{2}$.

11. Cranium of *Lamna cornubica* from the left side, with the upper and lower jaws, $\times \frac{2}{5}$. The reference letters have the same significance as in fig. 5.

Plate VI.

Carcharodon rondeletii.

Fig. 12. Posterior extremity of vertebral column, $\times \frac{1}{4}$. *Hæ*, hæmapophysis; *hæ.sp*, hæmal spine; *ptg*, pterygiophore or radial cartilage; *vert. cent.* 107, 130, & 167, the 107th, 130th, and 167th vertebral bodies.

13. Vertical section of a trunk vertebra, $\times \frac{1}{2}$.

14. Vertical section of a caudal vertebra, $\times \frac{1}{2}$.

15. The second dorsal fin, $\times \frac{5}{8}$.

16. The stomach and intestine, with the spleen and pancreas, from the ventral aspect, $\times \frac{1}{20}$. *b.d*, bile-duct; *card. st*, cardiac portion of stomach; *int*, intestine; *pan*, pancreas; *pyl.st*, pyloric portion of stomach; *rct*, rectum; *rct.gl*, rectal gland; *spl*, spleen; *x*, sac-like dilatations of stomach.

17. The cloaca with the rectal gland, urinary bladder, and extremities of the rectum and left oviduct, $\times \frac{1}{10}$. *cl*^{1}, inner, and *cl*^{2}, outer compartment of cloaca; *l.ovd*, left oviduct; *ovd.ap*, aperture of oviduct; *rct*, rectum; *rct.gl*, rectal gland; *ur.ap*, urinary aperture; *ur.bl*, urinary bladder.

18. The heart from the ventral aspect, the conus arteriosus being opened by a longitudinal incision, $\times \frac{1}{4}$. *aur*, auricle; *con.art*, conus arteriosus; *vcnt*, ventricle; v^1, v^2, v^3, the three rows of aortic valves.

Plate VII.

Carcharodon rondeletii.

Fig. 19. Transverse section of the caudal region, $\times \frac{1}{10}$.

20. The brain from the dorsal aspect, the tela vasculosa being removed on the left side, nat. size.

21. Anterior part of the brain with the cavities laid open from above, nat. size; a bristle (*x*, *y*) is passed from the mesocœle into the diacœle.

Fig. 22. The brain from the ventral aspect, nat. size.
23. The roots of the 5th, 7th, and 8th nerves, from the left side, nat. size.

References to Figs. 20–23.—*a*, elevation on inner wall of prosocœle; *aula*, remains of the cavity of the unpaired cerebral vesicle; *b*, elevation on floor of prosocœle; *b.opt*, basi-opticus (=ventral portion of mesencephalon); *ch.plx*, choroid plexus; *dien*, diencephalon (=thalamencephalon); *di.cœ*, diacœle (=third ventricle); *epen*, epencephalon (cerebellum); *for.M*, foramen of Monro; *hyp*, hypophysis cerebri; *mes.cœ*, mesocœle; *meten*, metencephalon (=medulla oblongata); *mt.cœ*, metacœle (=fourth ventricle); *opten*, optencephala (=optic lobes); *prosen*, prosencephala (=cerebral hemispheres), united into a single cerebrum; *prs.cœ*, prosocœle (=lateral ventricle); *rhinen*, rhinencephalon; *rh.cœ*, rhinocœle; *tel.vasc*, tela vasculosa; *vel.int*, velum interpositum; *i.–x.*, cerebral nerves.

PLATE VIII.

Carcharodon rondeletii (fœtus).

Fig. 24. The cranium from the dorsal aspect, nat. size.
25. The cranium from the ventral aspect, nat. size. *font*, fontanelle; *a.s.c*, *p.s.c*, *h.s.c*, elevations of the anterior, posterior, and horizontal semicircular canals; *h.m*, facet for the hyomandibular.
26. Outer view of the right auditory capsule, nat. size. *h.m*, facet for the hyomandibular; *h.s.c*, elevation for the horizontal semicircular canal; *spir.cart*, spiracular cartilage.
27. The ventral region of the branchial skeleton, nat. size. *b.hy*, basihyal plate; *b.br.* 2, *b.br.* 5, basibranchial of the 2nd and 5th arches; *h.br.* 2, *h.br.* 4, hypobranchials; *c.hy*, ceratohyal; *c.br.* 1, *c.br.* 2, *c.br.* 5, ceratobranchials.
28. Posterior extremity of the vertebral column showing the last three true centra and the terminal demi-vertebra, ×5.
29. The brain from the dorsal aspect, nat. size.

3. On the Habits of the Tree Trapdoor Spider of Graham's Town[1]. By the Rev. NENDICK ABRAHAM.

[Received November 15, 1886.]

Among the very numerous species of Arachnida which are found through the Cape Colony there are several kinds of Trapdoor Spiders. There is a species which, for convenience, I have called the Tree Trapdoor Spider, about which I wish to give some notes. I have been unable to find any mention of this particular Spider in any of my books, or in any I have access to, and it has been until now unknown to our local or colonial naturalists, so far as I have been able to learn. Thinking it may be known to this Society, I have not presumed to name it; but having very carefully observed for many months this wonderful creature, I send you these notes.

Unlike other Trapdoor Spiders, these build their houses in trees. There are certain trees which are more favourable for building-purposes than others, though the trees chosen are various, but in each case the trees have a rough bark. The house is a very wonderful structure, though small, measuring not more than one and a half

[1] Communicated by Dr. A. Günther, F.R.S., V.P.Z.S., who stated that the Spider in question appeared to be *Moggridgia dyeri* (O. P. Cambridge, Ann. & Mag. Nat. Hist. (4) xvi. p. 319, pl. x. 1875).